# Mineral Resource Geology in Academia: An Impending Crisis and an Opportunity for (Some) Students

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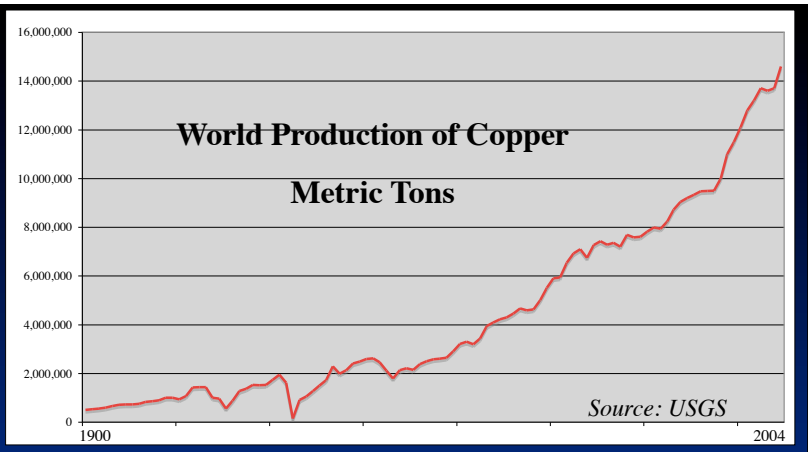
## Mineral Resources in the 21st Century

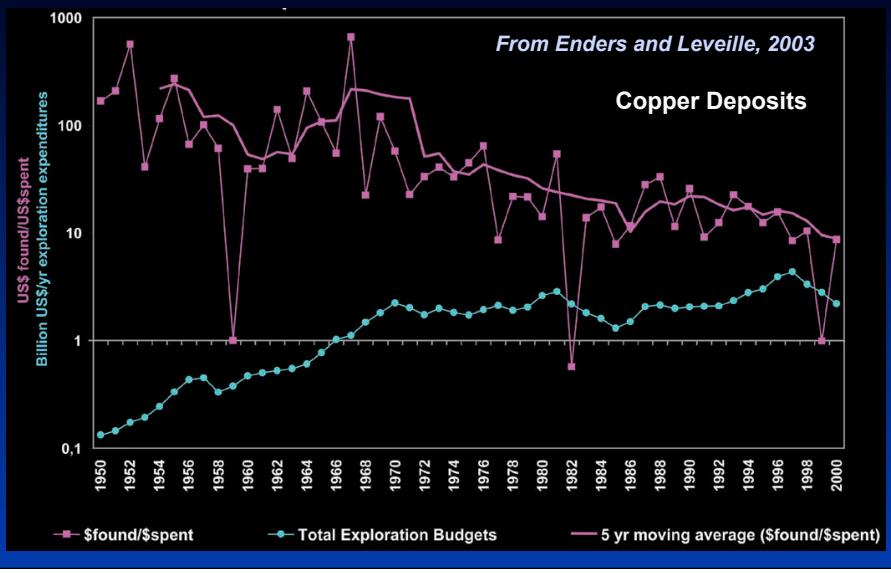
Geologically there are sufficient metallic mineral resources worldwide for the next century.

# Resource Availability




- Though stated reserves of different mineral commodities are taken to be finite, the reality is that industry has continued to supply these commodities at required levels (and at decreasing price) despite consistently increasing demand.
- We have not seen sustained disruptions of mineral commodities despite two World Wars and the Cold War.

# Exploration Costs Increase while Discoveries Go Down



## Mineral Exploration

Petroleum has success rates of over 90% for exploration wells.

Mineral exploration has success rates of less than 1% for exploration holes.

## A Fundamental Question for the Mining Industry —

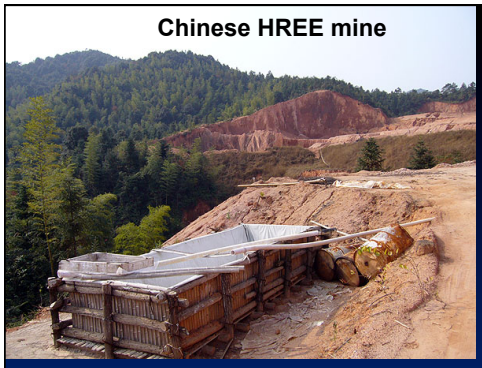
How do we move toward the exploration success rate of our petroleum brethren?

Although there is no inherent shortage of mineral resources, many resources have unequal distribution.


## Resource Distribution - Platinum Group Elements (PGE)

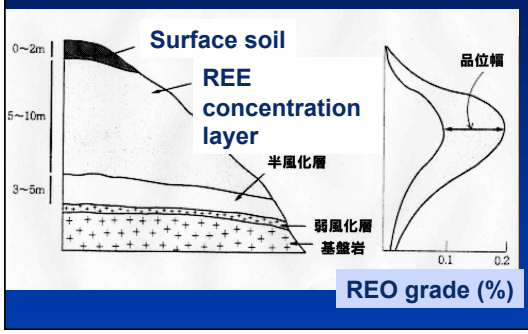
## Resource Distribution - Rare Earth Elements (REE)


For example, China currently produces 97% of the world's LREE and HREE.



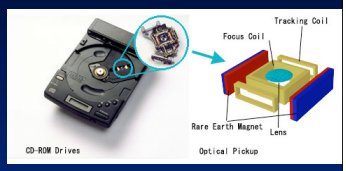

# HREE Production - China

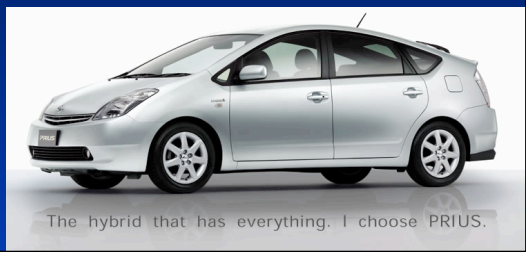
Low technology mining of weathered granite in southern China is the world's sole major source of heavy rare earth elements (Gd, Tb, Dy, Yb).




# HREE Production - China

These elements are essential components of our high technology world - hard drives, new magnets, hybrid vehicles.



## Resource Distribution

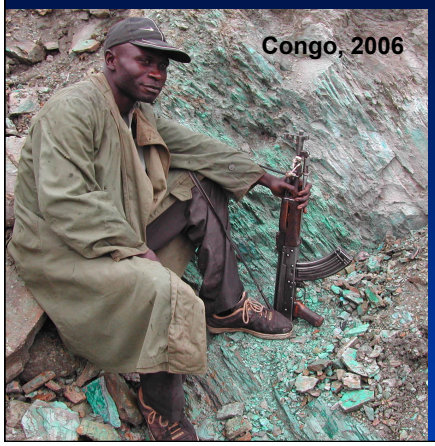
Many major economies (US, western Europe, Japan) are dependent for >90% of many mineral commodities.

**US Dependency >90% Imported**

| Commodity | Supplier |
|---|---|
| Antimony | China |
| Cobalt | Congo, Canada |
| Gallium | China |
| Germanium | Congo, Canada |
| Indium | China, Canada |
| REE | China |

## Resource Distribution

**US Dependency >90% Imported**

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**This could lead to significant economic / political conflict in the decades ahead.**

## Energy & Minerals

**Minerals important for new energy technologies —**

- **Batteries - Li, Ni, Co, Cd**
- **"High Tech" metals for fuel cells, composite materials, solar cells, etc. - HREE, LREE, Mg, Ti, Te, PGEs, "Coltan"**

**NEWS FLASH— Social issues:**

**New US law (Financial Regulatory Reform (July 2010) requires manufacturers to certify that the metals they use are not "conflict metals"**


## Economic Geology and Social Concerns

**Mining remains an industry with significant public relations issues - this is not likely to change in the near future.**

## Mines of the Future?
## Kennecott's Flambeau Mine (1991-1999)

Flambeau open pit

Reclaimed open pit

**Flambeau contained 1.9 million tonnes of 9.5% Cu and produced 181,000 tonnes Cu, 334,000 ounces of Au, and 3,300,000 ounces of Ag. Site now hosts recreation and wildlife habitat.**

## Economic Geology and Policy Decisions

**Changes in government policies can have a drastic effect (positive or negative) on mining (and your job prospects!).**

**LAW OF MONGOLIA**

**IMPOSITION OF PRICE INCREASE (WINDFALL) TAXES ON SOME COMMODITIES**

Article 1. Purpose of the Law

1.1 The purpose of the law is to regulate relations related to imposition of the tax on additional income of price increase for some commodities and its mobilization in a special fund.

***Exploration investment in Mongolia fell immediately and dramatically after adoption of this law in 2006.***

# (Economic Geology) Policy happening now in the US (last week)

FT.com FINANCIAL TIMES

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## Japan reacts over rare earths ban

By Mure Dickie in Tokyo
Published: September 28 2010 19:18 | Last updated: September 28 2010 19:18

China's de facto ban on rare-earth exports to Japan imposed during the two countries' diplomatic feud will propel Tokyo to seek new sources of the strategic minerals, according to Japan's new economics and fiscal policy minister.

In an interview with the Financial Times, minister of state Banri Kaieda called on China to lift export restrictions "as soon as possible".

# Economic Geology Policy happening now (last week)

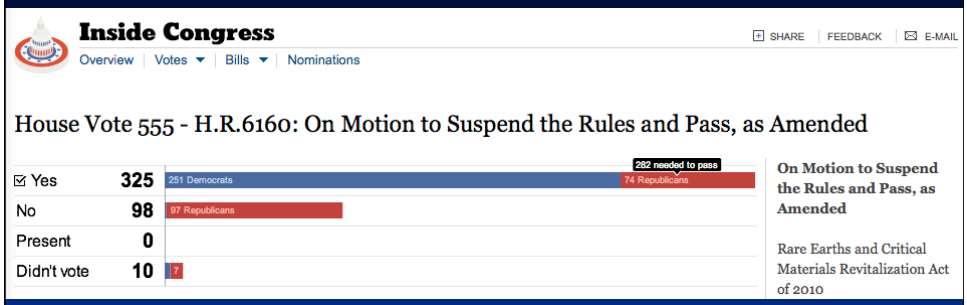
September 29, 2010 - Coffman Lauds House Passage of Rare Earths Research Bill

**Coffman Lauds House Passage of Rare Earths Research Bill**
*Calls on Colleagues to Pass Comprehensive RESTART Act*

**(WASHINGTON)** - Rep. Mike Coffman (R-CO) issued the following statement lauding the bipartisan passage of H.R. 6160, the Rare Earths and Critical Materials Revitalization Act of 2010, by the U.S. House of Representatives today. Coffman is an original co-sponsor of H.R. 6160 and author of H.R. 4866, the RESTART Act which through a series of broad measures would attempt to reestablish a competitive domestic rare earths supply chain:

"I applaud my colleagues for taking this step toward developing a comprehensive solution to the current rare earths crisis. I am encouraged that my colleagues have followed the provisions I worked to have included in last year's Defense Authorization bill and recognize the urgency of this crisis. Fostering increased research and development through the Department of Energy is an important step, but we must take additional action and address the entire supply chain. We must also further address the current regulatory environment and the endless stream of environmental litigation hampering exploration and development."

# Economic Geology Policy happening now




***Bipartisan vote on the Rare Earths Bill – a rare phenomena these days!***

# Mining in the 21st century must be:

- **Innovative**
- **Profitable**
- **Responsible and responsive to its social context**

***Societal and technological issues, rather than geological issues, will determine mining's future.***

## Mineral Resources in the 21st Century

Geologically there are sufficient metallic mineral resources worldwide for the next century.

**Mineral resource supplies for the next century will be controlled by political, economic, social, human resource, and technology issues.**

***Thus, training in academic economic geology must include not just the technical geologic aspects of our business.***

## Academic Economic Geology

So what is the situation in the academic side of economic geology?

## Data is based on a "Geology" article several US Academics published in Aug. 2009

GROUNDWORK

Furthering the Influence of Earth Science

### Mineral resource geology in academia: An impending crisis?

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(~15%) of the 2007 U.S. gross domestic product. The United States is the largest single consumer of mineral products and had a net trade deficit of US$43 billion in processed mineral materials in 2007—much smaller than the nation's oil bill, but still roughly one month's worth of the total U.S. trade deficit.

The United States is striving for increased energy independence, but it should also be concerned about mineral sustainability, as highlighted by the 2008 National Research Council report, "Minerals, Critical Minerals, and the U.S. Economy." The U.S. Geological Survey (USGS) indicates that the United States imported over 50% of 44 mineral commodities in 2007 and was 100% reliant on imports for 19 mineral commodities. For ex-

I would like to acknowledge the co-authors John Dilles (OSU), Mark Barton (UA), and Maeve Boland (CSM).

## 2002 Survey of Economic Geology Faculty in US and Canadian Universities

| 2002 Faculty Demographics* | Avg. | S.D. |
|---|---|---|
| Faculty Ph.D. year | 1982 | 8 |
| Hire year | 1985 | 10 |
| Expected retirement year | 2017 | 8 |
| Years of industry employment | 4.5 | 5 |

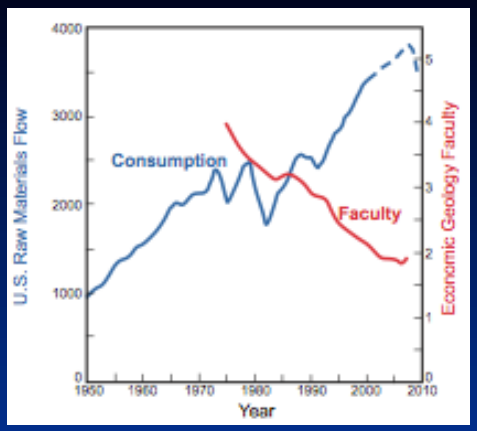
| | |
|---|---|
| Replacement would be hired in economic geology (probably, certainly) | 30% |
| Replacement would *not* be hired in economic geology (certainly not, almost certainly not, probably not) | 70% |

| Year-to-year comparisons | 1982 | 1992 | 2002 |
|---|---|---|---|
| M.S. students per faculty (avg. yearly) | 5.8 | 4.2 | 3.3 |
| Ph.D. students per faculty (avg. yearly) | 1.9 | 2.0 | 2.0 |
| Percent economic geology courses of total taught | | 33% | 24% |

*Note:* Based on 47 responses to an e-mail questionnaire sent to 102 U.S. and 45 Canadian universities by J.H. Dilles. Full survey data is available at www.geosociety.org/pubs/ft2009.htm as GSA Supplementary Data item 2009192. This survey also collected historical data. S.D.—standard deviation.

*$n$ = 47: 42 programs with 57 economic geology faculty.

## US Academic Economic Geology




Steady increase in U.S. consumption of raw materials (Wagner, 2002) and a steady decline in economic geologists as a percentage of total geoscience faculty (AGI, 1975-2007).

## US Academic Economic Geology

"… most professors who considered their principal specialty to be economic geology did 75% of their teaching in their secondary fields of geochemistry or petrology/mineralogy and relied principally on government grants for research funding."

"… 70% of these professors predicted their position would not be filled with an economic geologist when they retired in an average of 15 years."

*Hitzman et al., 2009*

## US Economic Geology Graduate Students

"… ~150 graduate students were in working in economic geology in the United States (in 2006)."

"… the United States is graduating fewer than 40 graduate-level economic geologists a year (in 2006). This is probably less than half the number required to offset annual retirements in the domestic mining industry alone, much less in other organizations that require related expertise."

*Hitzman et al., 2009*

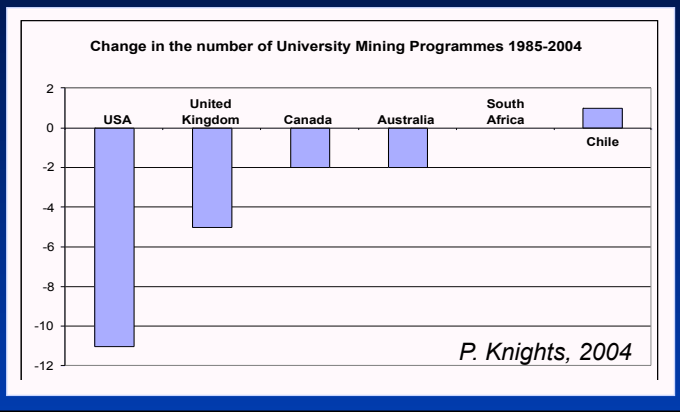
## US Economic Geology Graduate Students

"… Presently, many of the remaining U.S. academic programs in economic geology receive industry funding. However, most corporate-sponsored research is highly applied, limited in time and scope, and frequently does not include full overhead to the academic institution. Such "underfunded" research projects are rarely viewed favorably by academic administrations struggling to makes ends meet. Moreover, industry funding is often directed to other countries such as Canada and Australia, where matching funds from governments are typically available. Although the mining industry can help by increasing research funding, it might be more effective for it to support the restoration of dedicated federal funding…"

*Hitzman et al., 2009*

# Academic Mining Programs Worldwide

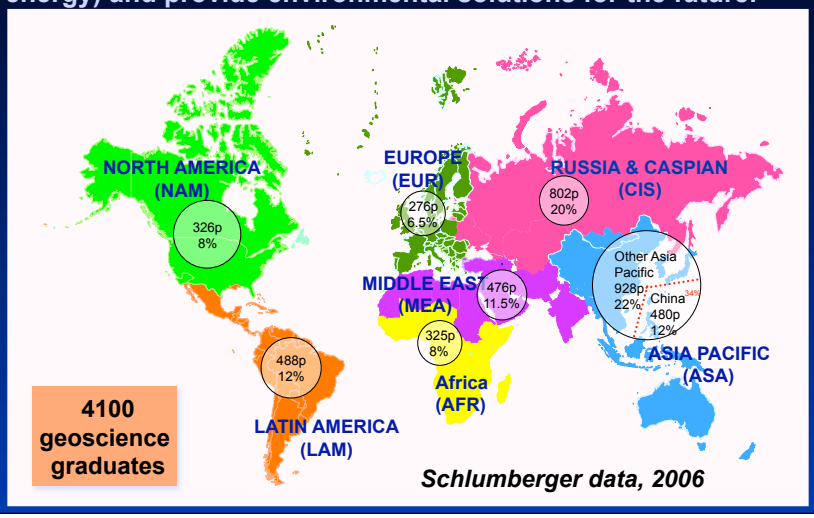
- Fewer individuals in the developed world are seeking a future in the minerals industry.
- As the current population of professionals is "greying" we are not seeing the required number of young people entering the field in the developed world to replace them. This is reflected in loss of university programs in the western world.




# The Challenge of Human Resources

Total number of geoscience graduates worldwide in 2004 - 4001 students!

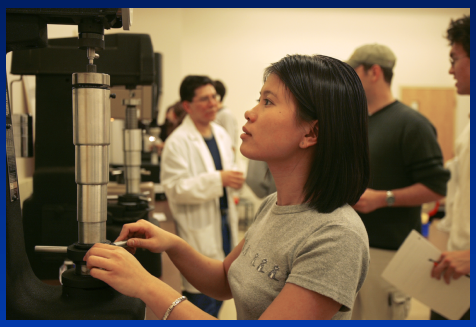
Very low number to discover and exploit world resources (metallic and energy) and provide environmental solutions for the future.

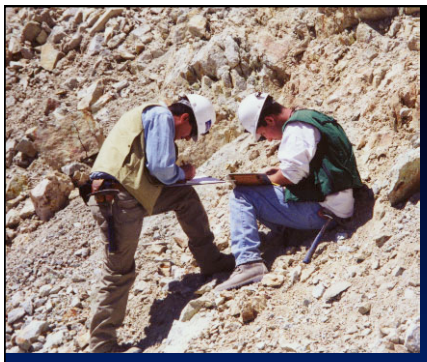


# Economic Geologists of the Future

Geologists in the mining industry of the future will have to look more like today's petroleum geologists:

- More integrative
- More ability to work in teams (particularly with mining engineers, hydrogeologists, geophysicists, mineral processors, and social and environmental scientists)
- Good computing skills



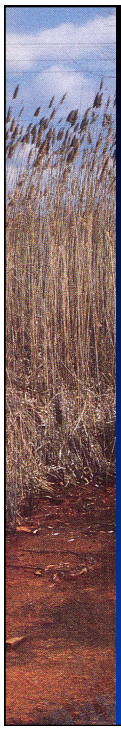


These geologists will also need today's (and yesterday's) skills of field mapping, familiarity with ore deposit models, 4-D interpretation, and geological intuition.

They will also need superb social and humanistic skills to deal with the issues associated with being the first representative of companies to interact with local populations and government officials.

## A Fundamental Question—

Is academia training enough people with the right technical and social skills to meet the challenges of the 21st century?



## The Challenge for the Next Century

Despite the geologic availability of mineral resources, the minerals industry of the future will require visionary leadership and an influx of high-quality imaginative professionals to identify mineral resources that can be extracted in socially and environmentally acceptable means at low cost.

## Challenges and Opportunities

The demographics indicate there will be abundant job opportunities for students graduating now and in the near future in economic geology.

The job market will include the mining industry, government (regulatory and research), academia (small pool of jobs), and "non-traditional" (NGOs, financial sector, IT sector).

Challenge will be securing placement in small group of high-quality academic economic geology programs worldwide — especially programs that provide the broad training in technical geoscience and non-geoscience aspects of the profession.

Challenge also in riding the inevitable ups and downs of the commodities markets.

## In Conclusion

"We invite the minerals industry, government, and institutions with a stake in mineral resources to initiate a dialogue and develop a new strategy, perhaps mediated through the National Research Council, to take U.S. academic economic geology successfully into the twenty-first century. " *Hitzman et al., 2009*

We in the US Academic Economic Geology community are working on these issues. This past week the NRC received funding (sought for 5 years!) for a study on workforce issues in the mining and energy industries.

However, the future is yours — you need to do your part — contact your elected representatives wherever you live and make them aware of the issues.

And for the US citizens in the audience – VOTE on Nov. 2!